

WHAT IS CLAIMED IS:

- 1 ^{5/27} 1. A method of determining a network performance metric in a network,
2 wherein said network comprises a plurality of network elements and each one of said
3 network elements is coupled to at least one other of said network elements by at least
4 one of a plurality of links, comprising:
5 measuring a measured network performance metric between a first network
6 element and a second network element of a network element pair in a
7 first set of network element pairs, wherein
8 said first network element and said second network element of said
9 network element pair in said first set of network element pairs
10 is included in said network elements, and
11 said measured network performance metric is such that a computed
12 network performance metric between a first network element
13 and a second network element of said network elements can be
14 computed using said measured network performance metric.
- 1 2. The method of claim 1, wherein
2 said computed network performance metric can be computed between
3 a first network element and a second network element of a
4 network element pair in a second set of network element pairs
5 using said measured network performance metric, and
6 said first network element and said second network element of said
7 network element pair in said second set of network element
8 pairs is included in said network elements.
- 1 3. The method of claim 2, further comprising:
2 computing said computed network performance metric between said first
3 network element and said second network element of said network
4 element pair in said second set of network element pairs, wherein
5 said second set of network element pairs are included in said network
6 elements, and

7 said first set of network element pairs is included in a second set of
8 network element pairs.

1 4. The method of claim 3, further comprising:
2 identifying pairs of said network elements as being in said second set of
3 network element pairs; and
4 identifying pairs of said network elements in said second set of network
5 element pairs as being in said first set of network element pairs.

1 5. The method of claim 4, further comprising:
2 generating a first matrix using said second set of network element pairs,
3 wherein
4 *B₂* each row in said first matrix corresponds to a corresponding network
5 element pair in said second set of network element pairs,
6 said first matrix comprises independent rows and non-independent
7 rows,
8 said first set of network element pairs contains independent network
9 element pairs in said second set of network element pairs, and
10 each one of said independent pairs of network element corresponds to a
11 one of said independent rows of said first matrix.

1 6. The method of claim 5, wherein said measured network performance
2 metric is measured between a first network element and a second network element of
3 each network element pair in said first set of network element pairs.

1 7. The method of claim 5, said method further comprising:
2 computing a number, wherein said number is equal to a rank of said first
3 matrix;
4 determining if a first said number of rows of said first matrix are independent;
5 and

6 if said first said number of said rows of said first matrix are not independent,
 7 re-arranging said rows of said first matrix such that said first said
 8 number of said rows of said first matrix are independent.

1 8. The method of claim 7, further comprising:
 2 identifying a maximal set of independent rows of said first matrix based on
 3 said number.

1 9. The method of claim 7, wherein said rearranging further comprises:
 2 re-arranging said pairs of said network elements in said second set of network
 3 element pairs such that said correspondence between each row of said
 4 first matrix and said corresponding network element pair in said second
 5 set of network element pairs is maintained.

1 ^{B2} 10. The method of claim 9, wherein said forming said first set of network
 2 element pairs comprises:
 3 copying a first said number of pairs of said network elements in said second
 4 set of network element pairs into said first set of network element
 5 pairs.

1 11. The method of claim 5, wherein
 2 said network element pair in said second set of network element pairs is a
 3 remaining network element pair in said second set of network element
 4 pairs, and
 5 said remaining network element pair corresponds to a non-independent row of
 6 said first matrix

1 12. The method of claim 6, wherein said computing said computed
 2 network performance metric between said first network element and said second
 3 network element of said remaining network element pair comprises:
 4 forming a second matrix, wherein

5 each row of said second matrix corresponds to a corresponding one of
 6 said non-independent rows of said first matrix, and
 7 said each row of said second matrix is such that said corresponding one
 8 of said non-independent rows of said first matrix can be
 9 expressed in terms of said independent rows using said each
 10 row of said second matrix;
 11 organizing said measured network performance metrics into a vector; and
 12 computing said computed network performance metric between said first
 13 network element and said second network element of said remaining
 14 network element pair by multiplying said vector by a row of said
 15 second matrix corresponding to said remaining network element pair.

1 13. The method of claim 6, wherein said computing said computed
 2 network performance metric between said first network element and said second
 3 network element of said remaining network element pair comprises:
 4 creating a vector equivalent to said non-independent row of said first matrix by
 5 combining a plurality of said independent rows of said first matrix; and
 6 computing said computed network performance metric by combining a
 7 measured network performance metric of each network element pair of
 8 said first set of network element pairs corresponding to one of said
 9 plurality of said independent rows of said first matrix.

1 14. A method of determining a network performance metric in a network,
 2 wherein said network comprises a plurality of network elements and each one of said
 3 network elements is coupled to at least one other of said network elements by at least
 4 one of a plurality of links, comprising:
 5 identifying pairs of said network elements as being in a first set of network
 6 element pairs;
 7 generating a first matrix from said first set of network element pairs, wherein
 8 each row in said first matrix corresponds to a corresponding network
 9 element pair in said first set of network element pairs, and

10 said first matrix comprises independent rows and non-independent
 11 rows;
 12 forming a second set of network element pairs, wherein
 13 said second set of network element pairs contains independent network
 14 element pairs in said first set of network element pairs, and
 15 each one of said independent pairs of network element corresponds to a
 16 one of said independent rows of said first matrix;
 17 measuring a measured network performance metric between a first network
 18 element and a second network element of each network element pair in
 19 said second set of network element pairs; and
 20 computing a computed network performance metric between a first network
 21 element and a second network element of a remaining network element
 22 pair in said first set of network element pairs using at least one of said
 23 measured network performance metrics, wherein said remaining
 24 network element pair corresponds to a non-independent row of said
 25 first matrix.

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1 15. The method of claim 14, wherein said first set of network element pairs
 2 is a requirements set.

1 16. The method of claim 15, wherein said second set of network element
 2 pairs is a measurements set.

1 17. The method of claim 16, wherein each one of said network elements is
 2 a router.

1 18. The method of claim 14, wherein said first matrix is a matrix F.
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1 19. The method of claim 14, said method further comprising:
 2 computing a number, wherein said number is equal to a rank of said first
 3 matrix;

determining if a first said number of rows of said first matrix are independent;
and
if said first said number of said rows of said first matrix are not independent,
re-arranging said rows of said first matrix such that said first said
number of said rows of said first matrix are independent.

20. The method of claim 19, further comprising:
identifying a maximal set of independent rows of said first matrix based on
said number.

21. The method of claim 19, wherein said rearranging further comprises:
re-arranging said pairs of said network elements in said first set of network
element pairs such that said correspondence between each row of said
first matrix and said corresponding network element pair in said first
set of network element pairs is maintained.

22. The method of claim 21, wherein said forming said second set of
network element pairs comprises:
copying a first said number of pairs of said network elements in said first set
of network element pairs into said second set of network element pairs.

23. The method of claim 14, wherein said computing said computed
network performance metric between said first network element and said second
network element of said remaining network element pair comprises:
forming a second matrix, wherein
each row of said second matrix corresponds to a corresponding one of
said non-independent rows of said first matrix, and
said each row of said second matrix is such that said corresponding one
of said non-independent rows of said first matrix can be
expressed in terms of said independent rows using said each
row of said second matrix;
organizing said measured network performance metrics into a vector; and

12 computing said computed network performance metric between said first
 13 network element and said second network element of said remaining
 14 network element pair by multiplying said vector by a row of said
 15 second matrix corresponding to said remaining network element pair.

1 24. The method of claim 23, wherein said second matrix is a matrix A.

1 25. The method of claim 14, wherein said computing said computed
 2 network performance metric between said first network element and said second
 3 network element of said remaining network element pair comprises:
 4 creating a vector equivalent to said non-independent row of said first matrix by
 5 combining a plurality of said independent rows of said first matrix; and
 6 computing said computed network performance metric by combining a
 7 measured network performance metric of each network element pair of
 8 said second set of network element pairs corresponding to one of said
 9 plurality of said independent rows of said first matrix.

1 26. The method of claim 14, wherein each one of said network elements is
 2 a router.

1 27. A computer system comprising:
 2 a processor;
 3 a network interface, coupled to said processor and to a network, wherein said
 4 network comprises a plurality of network elements and each one of
 5 said network elements is coupled to at least one other of said network
 6 elements by at least one of a plurality of links;
 7 computer readable medium coupled to said processor; and
 8 computer code, encoded in said computer readable medium, configured to
 9 cause said processor to:
 10 identify pairs of said network elements as being in a first set of
 11 network element pairs;

12 generate a first matrix from said first set of network element pairs,
 13 wherein
 14 each row in said first matrix corresponds to a corresponding
 15 network element pair in said first set of network element
 16 pairs, and
 17 said first matrix comprises independent rows and non-
 18 independent rows;
 19 form a second set of network element pairs, wherein
 20 said second set of network element pairs contains independent
 21 network element pairs in said first set of network
 22 element pairs, and
 23 each one of said independent pairs of network element
 24 corresponds to a one of said independent rows of said
 25 first matrix;
 26 measure a measured network performance metric between a first
 27 network element and a second network element of each
 28 network element pair in said second set of network element
 29 pairs; and
 30 compute a computed network performance metric between a first
 31 network element and a second network element of a remaining
 32 network element pair in said first set of network element pairs
 33 using at least one of said measured network performance
 34 metrics, wherein said remaining network element pair
 35 corresponds to a non-independent row of said first matrix.

1 28. The computer system of claim 27, wherein said first set of network
 2 element pairs is a requirements set.

1 29. The computer system of claim 28, wherein said second set of network
 2 element pairs is a measurements set.

1 30. The computer system of claim 29, wherein each one of said network
2 elements is a router.

1 31. The computer system of claim 27, wherein said first matrix is a matrix
2 F.

1 32. The computer system of claim 27, wherein said computer code is
2 further configured to cause said processor to:
3 compute a number, wherein said number is equal to a rank of said first matrix;
4 determine if a first said number of rows of said first matrix are independent;
5 and
6 if said first said number of said rows of said first matrix are not independent,
7 re-arrange said rows of said first matrix such that said first said number
8 of said rows of said first matrix are independent.

1 33. The computer system of claim 32, wherein said computer code is
2 further configured to cause said processor to:
3 identify a maximal set of independent rows of said first matrix based on said
4 number.

1 34. The computer system of claim 32, wherein said computer code
2 configured to cause said processor to re-arrange said rows of said first matrix such
3 that said first said number of said rows of said first matrix are independent, if said first
4 said number of said rows of said first matrix are not independent, is further configured
5 to cause said processor to:
6 re-arrange said pairs of said network elements in said first set of network
7 element pairs such that said correspondence between each row of said
8 first matrix and said corresponding network element pair in said first
9 set of network element pairs is maintained.

1 35. The computer system of claim 34, wherein said computer code
2 configured to cause said processor to form said second set of network element pairs is
3 configured to cause said processor to:

4 copy a first said number of pairs of said network elements in said first set of
5 network element pairs into said second set of network element pairs.

1 36. The computer system of claim 27, wherein said computer code
2 configured to cause said processor to compute said computed network performance
3 metric between said first network element and said second network element of said
4 remaining network element pair is configured to cause said processor to:

5 form a second matrix, wherein

6 each row of said second matrix corresponds to a corresponding one of
7 said non-independent rows of said first matrix, and
8 said each row of said second matrix is such that said corresponding one
9 of said non-independent rows of said first matrix can be
10 expressed in terms of said independent rows using said each
11 row of said second matrix;

12 organize said measured network performance metrics into a vector; and
13 compute said computed network performance metric between said first
14 network element and said second network element of said remaining
15 network element pair by multiplying said vector by a row of said
16 second matrix corresponding to said remaining network element pair.

1 37. The computer system of claim 36, wherein said second matrix is a
2 matrix A.

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1 38. The computer system of claim 27, wherein said computer code
2 configured to cause said processor to compute said computed network performance
3 metric between said first network element and said second network element of said
4 remaining network element pair is further configured to configured to cause said
5 processor to:
6 create a vector equivalent to said non-independent row of said first matrix by
7 combining a plurality of said independent rows of said first matrix; and
8 compute said computed network performance metric by combining a
9 measured network performance metric of each network element pair of
10 said second set of network element pairs corresponding to one of said
11 plurality of said independent rows of said first matrix.

1 39. The computer system of claim 27, wherein each one of said network
2 elements is a router.

1 40. A computer program product encoded in computer readable media,
2 said computer program product comprising:
3 a first set of instructions, executable on a computer system, configured to
4 identify pairs of said network elements as being in a first set of
5 network element pairs, wherein
6 said computer system is coupled to a network, wherein said network
7 comprises a plurality of network elements and each one of said
8 network elements is coupled to at least one other of said
9 network elements by at least one of a plurality of links;
10 a second set of instructions, executable on said computer system, configured to
11 generate a first matrix from said first set of network element pairs,
12 wherein
13 each row in said first matrix corresponds to a corresponding network
14 element pair in said first set of network element pairs, and
15 said first matrix comprises independent rows and non-independent
16 rows;

17 a third set of instructions, executable on said computer system, configured to
 18 form a second set of network element pairs, wherein
 19 said second set of network element pairs contains independent network
 20 element pairs in said first set of network element pairs, and
 21 each one of said independent pairs of network element corresponds to a
 22 one of said independent rows of said first matrix;
 23 a fourth set of instructions, executable on said computer system, configured to
 24 measure a measured network performance metric between a first
 25 network element and a second network element of each network
 26 element pair in said second set of network element pairs; and
 27 a fifth set of instructions, executable on said computer system, configured to
 28 compute a computed network performance metric between a first
 29 network element and a second network element of a remaining network
 30 element pair in said first set of network element pairs using at least one
 31 of said measured network performance metrics, wherein said remaining
 32 network element pair corresponds to a non-independent row of said
 33 first matrix.

1 41. The computer program product of claim 40, wherein said first set of
 2 network element pairs is a requirements set.

1 42. The computer program product of claim 41, wherein said second set of
 2 network element pairs is a measurements set.

1 43. The computer program product of claim 42, wherein each one of said
 2 network elements is a router.

1 44. The computer program product of claim 40, wherein said first matrix is
 2 a matrix F.

45. The computer program product of claim 44, further comprising:
a sixth set of instructions, executable on said computer system, configured to
compute a number, wherein said number is equal to a rank of said first
matrix;
a seventh set of instructions, executable on said computer system, configured
to determine if a first said number of rows of said first matrix are
independent; and
an eighth set of instructions, executable on said computer system, configured
to re-arrange said rows of said first matrix such that said first said
number of said rows of said first matrix are independent, if said first
said number of said rows of said first matrix are not independent.

46. The computer program product of claim 45, further comprising:
a ninth set of instructions, executable on said computer system, configured to
identify a maximal set of independent rows of said first matrix based
on said number.

47. The computer program product of claim 45, wherein said eighth set of
instructions comprises:
a first sub-set of instructions, executable on said computer system, configured
to re-arrange said pairs of said network elements in said first set of
network element pairs such that said correspondence between each row
of said first matrix and said corresponding network element pair in said
first set of network element pairs is maintained.

48. The computer program product of claim 47, wherein said third set of
instructions comprises:
a second sub-set of instructions, executable on said computer system,
configured to copy a first said number of pairs of said network
elements in said first set of network element pairs into said second set
of network element pairs.

1 49. The computer program product of claim 40, wherein said fifth set of
2 instructions comprises:
3 a first sub-set of instructions, executable on said computer system, configured
4 to form a second matrix, wherein
5 each row of said second matrix corresponds to a corresponding one of
6 said non-independent rows of said first matrix, and
7 said each row of said second matrix is such that said corresponding one
8 of said non-independent rows of said first matrix can be
9 expressed in terms of said independent rows using said each
10 row of said second matrix;
11 a second sub-set of instructions, executable on said computer system,
12 configured to organize said measured network performance metrics
13 into a vector; and
14 an third sub-set of instructions, executable on said computer system,
15 configured to compute said computed network performance metric
16 between said first network element and said second network element of
17 said remaining network element pair by multiplying said vector by a
18 row of said second matrix corresponding to said remaining network
19 element pair.

1 50. The computer program product of claim 49, wherein said second
2 matrix is a matrix A.

1 51. The computer program product of claim 40, wherein said fifth set of
2 instructions comprises:
3 a first sub-set of instructions, executable on said computer system, configured
4 to create a vector equivalent to said non-independent row of said first
5 matrix by combining a plurality of said independent rows of said first
6 matrix; and
7 a second-subset of instructions, executable on said computer system,
8 configured to compute said computed network performance metric by

combining a measured network performance metric of each network element pair of said second set of network element pairs corresponding to one of said plurality of said independent rows of said first matrix.

52. The computer program product of claim 40, wherein each one of said network elements is a router.

53. A computer system comprising:
a network interface, coupled to said processor and to a network, wherein said network comprises a plurality of network elements and each one of said network elements is coupled to at least one other of said network elements by at least one of a plurality of links;
means for identifying pairs of said network elements as being in a first set of network element pairs;
means for generating a first matrix from said first set of network element pairs, wherein
each row in said first matrix corresponds to a corresponding network element pair in said first set of network element pairs, and said first matrix comprises independent rows and non-independent rows;
means for forming a second set of network element pairs, wherein said second set of network element pairs contains independent network element pairs in said first set of network element pairs, and each one of said independent pairs of network element corresponds to a one of said independent rows of said first matrix;
means for measuring a measured network performance metric between a first network element and a second network element of each network element pair in said second set of network element pairs; and
means for computing a computed network performance metric between a first network element and a second network element of a remaining network element pair in said first set of network element pairs using at least one of said measured network performance metrics, wherein said remaining

26 network element pair corresponds to a non-independent row of said
27 first matrix.

1 54. The computer system of claim 53, further comprising:
2 compute a number, wherein said number is equal to a rank of said first matrix;
3 means for determining if a first said number of rows of said first matrix are
4 independent; and
5 means for re-arranging said rows of said first matrix such that said first said
6 number of said rows of said first matrix are independent, if said first
7 said number of said rows of said first matrix are not independent.

1 55. The computer system of claim 54, wherein said computer code is
2 further configured to cause said processor to:
3 means for identifying a maximal set of independent rows of said first matrix
4 based on said number.

1 56. The computer system of claim 54, wherein said means for re-arranging
2 said rows of said first matrix such that said first said number of said rows of said first
3 matrix are independent, if said first said number of said rows of said first matrix are
4 not independent, further comprises:
5 means for re-arranging said pairs of said network elements in said first set of
6 network element pairs such that said correspondence between each row
7 of said first matrix and said corresponding network element pair in said
8 first set of network element pairs is maintained.

1 57. The computer system of claim 56, wherein said means for forming said
2 second set of network element pairs further comprises:
3 means for copying a first said number of pairs of said network elements in said
4 first set of network element pairs into said second set of network
5 element pairs.

1 58. The computer system of claim 53, wherein said means for computing
2 said computed network performance metric between said first network element and
3 said second network element of said remaining network element pair further
4 comprises:

5 means for forming a second matrix, wherein

6 each row of said second matrix corresponds to a corresponding one of
7 said non-independent rows of said first matrix, and

8 said each row of said second matrix is such that said corresponding one
9 of said non-independent rows of said first matrix can be
10 expressed in terms of said independent rows using said each
11 row of said second matrix;

12 means for organizing said measured network performance metrics into a
13 vector; and

14 means for computing said computed network performance metric between said
15 first network element and said second network element of said
16 remaining network element pair by multiplying said vector by a row of
17 said second matrix corresponding to said remaining network element
18 pair.

1 59. The computer system of claim 53, wherein said means for computing
2 said computed network performance metric between said first network element and
3 said second network element of said remaining network element pair further
4 comprises:

5 means for creating a vector equivalent to said non-independent row of said
6 first matrix by combining a plurality of said independent rows of said
7 first matrix; and

8 means for computing said computed network performance metric by
9 combining a measured network performance metric of each network
10 element pair of said second set of network element pairs corresponding
11 to one of said plurality of said independent rows of said first matrix.